Chapter 2
Natural Interaction for Medical Simulation and Training

Abstract Skills training is of primary importance for healthcare professionals. New technologies such as natural interfaces and virtual reality bring new possibilities in learning outcomes especially if used synergically exploiting some principles derived from the so-called serious gaming interfaces. Virtual reality combined with natural interaction interfaces, through which natural gestures can be used to control interaction, have been primarily used in the medical field for the development of rehabilitation systems. However, such technologies are also promising for the implementation of decision support and skill training systems since they can improve users engagement in task completion and team based activities through immersivity and physical participation. In this chapter we are going to give an overview of the current state of medical simulation, considering issues and new perspectives, and to explain why immersive digital systems and natural interaction are important and can contribute to improving medical training. A large literature on immersive and natural interaction systems is reviewed highlighting good practices and limits. New opportunities offered by the recent development of virtual reality, especially if combined with computer vision systems, are introduced.

Keywords Natural interaction · Immersive environments · Virtual reality

2.1 Introduction

Medical simulations have been enacted for centuries, even in primitive forms [1]. Practice is a key component for the maintenance and learning of skills in medicine [2], and in this regard, medical simulation encompasses different solutions. According to the pioneer David Gaba [3], there are five categories of simulation in medicine: verbal simulations, standardized patients, part-task trainers, electronic patients, and computer patients. A verbal simulation is a role-playing game between trainees. Standardized patients are actors employed to train junior doctors in communication and physical examination skills as well as patient history taking. Task trainers usually are lifelike models of body parts, such as an arm or pelvis, and the most complex versions are also used as surgical trainers, use mechanics, and can be useful

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in teaching biological processes. Electronic patients are probably the most realistic devices for simulations. They are full-size heavy mannequins[1] with human-like behavior (e.g., providing eye blinking, breathe, and pulse) and are usually computer controlled in order to induce disease symptoms. Electronic patients and dedicated electronic devices such as task trainers allow to carry out rather plausible simulations. Compared to standardized patients and verbal simulations, they can return symptoms and body reactions not otherwise reproducible in a feasible and realistic way using actors. They also allow to repeat simulations as often as it is needed without additional staff costs. On the other hand, these simulators are very expensive and not easily sustainable with regard to maintenance costs. Computer patients, especially if exploiting VR and natural interaction, can be used to reduce this cost: in fact they can provide virtual software based interactive characters capable of giving the same visual, auditory and sensory feedback of standardized and electronic patients with an acceptable degree of realism at a much lower overall and maintenance cost.

Simulation in medical training has really improved in both fidelity and performance, though there are still several issues that entail an in some cases justified skepticism in its adoption during the training process. Nonetheless, several schools of medicine all around the world are integrating simulations in doctor training and even offer certifications recognized by simulation centers [4]. The main reason of the delay in this adoption is related to several factors such as the cost of professional training personnel and the cost of the equipment and its maintenance (e.g., for the purchase and maintenance of electronic mannequins for patients simulations or the use of special devices for interaction such as motors and haptic controllers). These problems can be largely mitigated through the adoption of computer patients exploiting latest technological progresses in natural interaction (NI), 3D computer graphics, and VR applied to simulations. In fact, new paradigms of interaction and improvements in the realism of virtual environments can now inspire to engineers and professionals the design of software-based learning tools for activities training ranging from medium to high complexity, also in the medical field. In this book, we give some suggestions on how to exploit advanced techniques such as natural interaction and computer vision applied to two VR scenarios pointing out also the limits that these technologies may present in other scenarios.

However, despite some limitations we are going to explain in the rest of the book, it is evident that natural and VR interfaces can reduce the cost of simulation replacing expensive infrastructures, interaction controllers, and necessary medical equipment devices with virtual worlds. Moreover, simulation of dangerous and extreme scenarios can be carried out without risk and with a higher level of contextual awareness and engagement provided by high-fidelity realistic rendering and natural interaction paradigms and techniques boosted by computer vision. In this way, the quality of the training of junior and professional personnel can be really improved. In particular, compared to simulations with mannequins, these computer systems allow to:

[1] 'Harvey mannequin' was one of the earliest electronic patients, currently sold by Laerdal Corporation.

- have an intelligent and configurable system that responds automatically to user actions;
- receive continuous audiovisual feedback from the ambient;
- simulate situations similar to those recreated with the use of mannequins, but at a lower cost, enhancing the realism of environments, of the interaction and of the communication through VR and NI. Consequently, this improves learnability and memorability of procedures;
- be corrected on the fly and have human-like system feedback in real time. Feedback is usually provided in the debriefing phase in standard medical training. In this part of the training, trainers and trainees discuss the simulation sessions. This approach assumes a period of time between the wrong action and the correction which instead is provided simultaneously during the computer-based simulation.

However, the effective gain in using these computer systems featuring VR and especially NI also depends on the simulation objectives. In fact, medical simulation systems can have different goals such as training communication between members of a team, providing situational awareness and teaching procedures, exercising on manual skills. Skills training in particular requires precise measurements and high-level human evaluation of procedures accomplishments. In these situations, a few millimeters of error may result in a critical outcome for the patient as in the case of a surgical operation. On the other hand, it is really difficult to obtain granular and effective virtual simulation for personal skill training using, for example, natural interaction (that it is not so accurate for understanding the movements of a surgeon's hands during e.g., a laparoscopy), while for improving intra-team members communication and situational awareness using the same technologies, there is usually the need of supporting a sufficient complexity in the scenario. In this latter case, there could be a proportionally growing difficulty in scenario understanding which, conversely, is an essential prerequisite for the adoption of NI and computer vision in VR simulators. For example, while assisting a pediatric patient, parents may interfere with the procedure, though at the same time they are probably the only and most accurate source of information on the patient's history and the cause of his/her condition. It can be quite challenging to reproduce this virtual scenario in an immersive environment and simultaneously to allow all these actors be enacted by trainees capable of interacting naturally with the VR interface. These are important points that have to be taken into account when considering the adoption of natural interaction applied to virtual environments for training. The two prototypes we are going to present in this book in Chap. 4 make use of these technologies but previous in-depth studies on usability and systems objectives as well as on the interaction design of simulations have been conducted in order to asses the effectiveness of these technologies in those scenarios with respect to the objectives and to ensure the feasibility of the final simulators. In fact, natural interaction, at the state of the art, is not so mature to be exploited in scenarios which require continuous high-fidelity gesture tracking and a high-level understanding of a complex situation. Furthermore, also when NI can be adopted, it may need adaptations to the context of use and the introduction of new design strategies as those we explain for the SSC-S simulator presented in Sect. 4.3.

It is, however, indisputable that computer simulation systems (also those not exploiting advanced features such as Virtual Reality and Natural Interaction which add realism and engagement with the systems) can offer great benefits with regard to the management and the cost of professional training. This is a point that should be stressed considering several aspects. For example, to improve medical operators' communication skills it is also important to be able to repeat simulations. Simulations may be repeated with the same configuration parameters or with slight variations. This kind of simulation and configuration is usually performed working on expensive electronic patients or mannequins under the supervision of professionals. Furthermore, instrumentation and configuration of the parameters have to be controlled in loco by instructors, impacting heavily on staff costs. McIntosh et al. [5] have analyzed the expenses related to 'classic' training systems of several simulation centers in a 2006 article. Results showed that the overall set-up cost for facilities and equipment was \$876,485. Fixed costs per year amounted at a total of \$361,425, while variable costs for session training and teaching totaled \$311 per course hour.

Simulation scenarios in which such systems can prove to be highly suitable and convenient can certainly be found in the field of emergency medicine training where they can be extremely useful to teach emergency medical technicians (EMTs) and medics to operate in harmful or critical situations. In fact, the use of computer simulators allows reproducing the environment of also extreme scenarios in a more realistic way (e.g., a plane crash or an earthquake). In fact, the use of computer simulators allows to reproduce the environment of also extreme scenarios in a realistic way (e.g., a plane crash or an earthquake). However, it should be said that for some aspects, as when an operator has to interact with the patient,virtual environments may also be poor in returning the realism of the simulation with respect to electronic patients, since it would be complicated, for example, to deliver the tactile information that a physical electronic mannequin, or a real human, can. Despite these considerations, VR is an essential way of reducing training costs while maintaining at the same time good performance in skill acquisition, even more valuable in the future if we consider its integration with NI interfaces, which is one of the subject of this book, and the fact that multimedia systems are more and more capable of providing realistic and multisensory feedback. Furthermore, through computer simulators (1) environmental conditions can be easily varied so to reinforce environmental awareness in the trainees; (2) number of patients in need of assistance and operators can be increased in the simulation with no cost at all especially if they are non-playing characters (NPC). As an example, let us imagine the scenario of a bus crash on a highway. Such a scenario requires the intervention of multiple medical operators with a high skill in managing and prioritizing patient assistance procedures. The enactment of such a simulation scenario would require a vast amount of free ground, several electronic patients, and actors together with trainees. Electronic mannequins are quite expensive since their cost ranges from 20k to 80k \$. Only a few medical schools and the military can afford such expenses. Therefore, simulations involving the use of electronic mannequins are usually enacted in the emergency room or in a bare room at the hospital with an availability of only one or two electronic patients. Furthermore, the possibility for operators to be confronted with situations involving many risks both for the patient and themselves can improve the trainees environmental awareness and the interrelational skills of the operators. These situations and the actual actions to be performed can be simulated realistically not only at no cost but without any risk for the trainees. An example is a Basic Life Support and Defibrillation (BLSD) scenario in an apartment of a burning building where simulation participants need to take care of their safety before assisting the patient requesting, if needed, firemen support (the same scenario is provided in description of our BLSD-S simulator in Sect. 4.2.2).

Dale [6] has carried out a comparative evaluation of methods of information delivery in education. On this basis, he has proposed his famous 'cone of experience' which highlights how higher learning outcomes are achieved when concepts are delivered in a form that is as close as possible to the real experience. Therefore, taking part in a realistic VR simulation which provides high quality graphics rather than trying to imagine a situation or worse passively watching videos or reading can increase the amount of information that can be effectively memorized by a student. Medical education can really benefit from new technologies providing immersive and natural interfaces which can allow trainers to teach and debrief well-defined procedures, as well as learners to acquire a high level of participation and control. Nowadays, this can be achieved through several types of solutions that allow different levels of perceptual and psychological immersion: 3D graphics visualized on standard displays, specialized rooms (e.g., Cave), or VR exploited through head-mounted displays (HMDs) together with interaction devices for the 3D world (e.g., Kinect, Razer Hydra, force feedback gloves, haptic devices).

In the following sections, we review and discuss different types of medical simulation systems, ranging from simple desktop applications to highly interactive virtual reality (VR) simulators. We are also going to introduce the concept of natural interaction and his application to the medical field. A summary of the presented simulations systems discussed in this chapter can be found in Table 2.1.

2.2 Applications for Medical Simulation and Training

2.2.1 Medical Simulation Systems

The literature in the field of medical training systems reveals, in recent years, an orientation toward the design of high configurable prototypes [3, 7–9]. These systems are difficult to implement and maintain due to the fact that medical procedures are becoming everyday more complex. On the other hand, very specialized systems [10, 11] have been designed in a way that makes them not adaptable and flexible enough to be deployed in different scenarios. Furthermore, for the most part, the majority of interfaces of these systems are not fully immersive and intuitive. Nonetheless, although they exploit different tools for interaction such as haptic sensors, cameras, and markers, they could benefit a lot from natural interaction techniques.

The Cybermed framework [7] is a system for medical training via computer network. It has advanced features for configuring some aspects of the simulation such as the number of users, the gestures to manipulate the objects, the type of devices (mouse or haptic systems) to be exploited, and the choice of the actors for remote mentoring and distance learning (tutor or participants) but it does not really allow an exhaustive characterization of the situation or the definition of complex medical procedures. SOFA [8], ViMet [9], and GiPSi [12] frameworks instead are open-source projects which feature a high level of modularity and rely on the capability of a multi-model representation of simulation models (deformable models, collision models, instruments).

Although they easily allow to simulate a scenario, say a laparoscopy, they neither provide a real natural and immersive interface nor they go beyond enabling the system to respond to punctual stimuli (e.g., in the laparoscopy use case, deformation of the liver, and collision with the ribs). Spring [10] is a more specific mouse-based desktop framework for real-time surgical simulations which provides a basic configurability for patient-specific anatomy. Laerdal MicroSim [11] is a non-immersive simulation system that presents to trainees pre-hospital, in-hospital, and military scenarios. In the pre-hospital scenario, the user can interact with the patient through a simple 2D interface and has a static view of the scene. Recent studies [13, 14] instead have proved the benefits of the use of game dynamics to boost the adoption of simple computer-based virtual patients by groups of students for medical training sessions.

With regard to more immersive solutions, Honey et al. have created a virtual environment in second life for hemorrhage management [15]; Cowan et al. [16] have developed a system for the inter-professional education (IPE) for critical care providers where an immersive 3D situation is accessed across the network in a 'multi-player online' environment, allowing trainees to participate, as avatars, from remote locations. Sliney et al. [17] propose a system, named JDoc, which uses realistic situations to train junior doctors in dealing with the frenzy of a first aid hospital. Immersivity and realism are one of the keypoints for users engagement in the development of these training systems. This is confirmed by Buttussi et al. [18] who obtained encouraging results evaluating a 3D serious game as a support tool for medicine students.

2.2.2 *Immersive Interactive Environments (IVEs) and Serious Gaming*

The concept of 'serious games' has been used since the 1960s whenever referring to solutions adopting gaming with educational purpose rather than pure players' entertainment [19]. Among the different fields of study in which serious games have been exploited, medicine is one the most prolific [20] counting a large number of applications that feature immersive virtual environments (IVEs). Improvements in medical training using gaming and IVEs have been brought out especially in the field of surgical education where IVEs already play a significant role in training programs [21, 22].

The Off-Pump Coronary Artery Bypass (OPCAB) game [23] and the Total Knee Arthroplasty game [24], for example, focus on the training of decision-taking dynamics in a virtual operating room. Serious games featuring IVEs about different topics are Pulse! [25], for acute care and critical care, CAVE™triage training [26], or Burn Center™ for the treatment of burn injuries [27]. Though all these medical training simulators focus on individual skills, an important aspect of health care to be taken into account is that, for the most, it has to be provided by teams. Common techniques of team training in hospitals include apprenticeship, role playing, and rehearsal and involve high costs due to the required personnel, simulated scenarios that often lack realism, and the large amount of time needed. Several serious games featuring IVEs for team training have also been developed in the last years. 3DiTeams [25], CliniSpace™[28], HumanSim [29], Virtual ED [30], and Virtual ED II [31] are some examples of gaming approaches in team training for acute and critical care whose main objective is to identify and reduce the weaknesses in operational procedures. A virtual environment for training combat medics has been developed by Wiederhold and Wiederhold [32] to prevent the eventuality of post-traumatic stress disorder. Medical team training for emergency first response has been developed as systems distributed over the network by Alverson et al. [33] and Kaufman et al. [34].

IVEs have proved to be an effective educational tool. Tasks can be repeated in a safe environment and as often as required. IVEs, as we have stressed in the previous section, allow to realistically experience a wide range of situations that would be impossible to replicate in the real world due to danger, complexity, and impracticability. Though IVEs have been traditionally associated with high costs due to the necessary hardware, especially to provide real-time interactivity (multiple projectors, input devices, etc.), and have always presented a difficult setup, in the last years these issues have been partially solved by the availability of cheap and easily deployable devices such as head-mounted displays (e.g., the Oculus Rift, the Samsung Gear VR) for VR and controllers or depth sensors (e.g., the Nintendo Wii or the Microsoft Kinect™) for providing interaction, context understanding, or reconstruction. A realistic representation of the environment and the naturalness of interaction, made possible by these devices, allows to create in learners the correct mental model and to reinforce the memorability of specific procedures. On the basis of the constructivism theory [35], one of the main features of educational IVEs is the possibility of providing highly interactive experiences capable to intellectually engage trainees in carrying out tasks and activities they are responsible for. The opportunity to navigate educational scenarios as first person controllers (especially through HMD) allows learners to have a more direct awareness of the interaction context and of their responsibilities than in sessions mediated through an un-related element such as a graphical user interface or an other symbolic representation. In this regard, IVEs present a less cognitive effort in elaborating the context and stimulate imagination. This is even more true in scenarios where not only skills are learned in the environment where these will be applied, but also the tasks can be carried out by the trainee acting in a natural way without the mediation of any device (e.g., keyboard, mouse, or other controllers). It is also pointed out by constructivists that learning is enhanced when gaming, group-work activity, and cooperation are provided. Interacting with humans is more interesting and involving than interacting with a computer, and it implies personal responsibility. Each learner is expected by others to account for his/her actions and to contribute to the achievement of the team goal. The use of gaming techniques in education is called 'edutainment,' and it is preferred by trainees to the traditional approaches because it increases students motivation and engagement in the learning context [36].

Despite the perceived advantages and the good appreciation of serious games featuring IVEs for training, the adoption of such systems is still poor in real medical facilities. This is due to the fact that some open issues still exist in the usability of systems exploiting latest technologies in NI and VR. For example: (1) NI provides poor accuracy in detecting complex gestures; (2) some open problems exist on how to move naturally in virtual spaces being constrained in physical spaces; (3) it is easy to get lost in VR due to the possibility of free movement; it is difficult to provide a significant set of options in VR environments without switching to traditional device-controlled 2D interfaces (e.g., panels visualizing multiple choices or drop-down menus). Things are even more complicated when we talk about multi-user systems for team training. Eventually, we can say that well-designed VR systems could benefit a lot adopting natural interaction techniques and exploiting new low-cost devices available on the market for navigating and controlling interfaces provided that the limitations of the technologies themselves are taken into account and interfaces are designed accordingly. In Chap. 3, we show how some techniques of computer vision applied to NI can improve the capabilities of these systems.

2.3 Natural Interaction Applications

2.3.1 Interaction Techniques and Devices

The basic idea of natural interaction (NI) is to create a more intuitive and natural human–computer communication, inspired by real-life interactions such as speech, gestures, and touch. The mutual progress in the field of human–computer interaction, computer vision, and pattern recognition has made possible to propose such technologies for providing natural gestures to control digital interfaces. Systems adopting natural interaction show increased efficiency, speed, power, and realism in many fields. Medical simulation systems, and educational application in general, can also benefit from the adoption of NI. Several Natural User Interfaces (NUIs) featuring natural interaction systems have been used in medical rehabilitation, although sparsely, leveraging different technologies (e.g., Nintendo Wii, PlayStation EyeToy), as part of physical therapy. Haptic sensors are commonly used in rehabilitation to ease the interaction with the systems [37, 38]. Markers and accelerometers/gyroscopes provided by the Nintendo Wii have been used to get information about scene orientation and objects positioning in order to augment and improve systems responsiveness [39] to human behaviors. These solutions, despite being easy to implement, have the disadvantage to be not completely natural, forcing users to wear or to hold different devices with their hands in order to interact with the systems [40]. A more natural way to interact is commonly obtained allowing user to perform gestures with their hands in an unobtrusive way. Early adopter of gesture-based interaction [41] mainly relied on wearable tracking systems. Hand gestures could be captured through movement sensors, including *data gloves* that precisely track movements of user's hand and fingers. Yanbin et al. [42] proposed a virtual simulation to train nurses and midwifes in accomplishing operations. The system used data gloves to track hands movement of trainees and created 3D reconstructions to assess difficult childbirth situations.

Computer vision (CV) techniques play a fundamental role in enabling natural interaction through hands tracking and body gesture recognition [43]. CV systems allow to capture user interaction in a completely non-intrusive and passive manner and can therefore represent an effective and low-cost technology in medical application and simulations in general [44]. Furthermore, CV systems can reduce required device capabilities and cost. Advanced pattern recognition pipelines in fact allow to sense user actions (e.g., the hand gestures used in our prototypes) through commercially available low-cost cameras. At the same time, cameras used for hand gesture recognition can be used for other interface functionalities. Hand gesture-based application has found use in different contexts in the medical field. In [45], authors introduced a CV-based application to let surgeons interact with computing devices through hand gestures. This allowed medical image visualization in the operating room without the need of touching any input device.

In the last decade, the introduction of low-cost depth cameras such as the Microsoft Kinect™ has paved the road for the development of increasingly more interactive simulator. Depth cameras allow a more robust tracking of the scene and of the user, making possible to implement novel ways of user interaction with computer interfaces. Kinect-enabled systems have been commonly used in medical rehabilitation. Lange et al. [46], for example, have developed a Kinect-based game "JewelMine" that consists of a set of balance training exercises to stimulate the players to reach out of their base of support. This kind of software takes advantage of the situation realism and the naturalness allowed by the Kinect sensor in gestures tracking. This is relevant especially to encourage physical exercise but it is an approach not quite common in medical operators training systems. LISSA [47] is a Kinect-based system developed to train specific skills in Cardiopulmonary Resuscitation (CPR). This system is one of the first medical training software exploiting motion tracking but compared to BLSD-S, our prototype presented in Sect. 4.2.2, LISSA is more skill-oriented rather than procedure-oriented.

In this book, we show how computer vision can be exploited in NI-enabled VR systems augmenting the capabilities of state-of-the-art devices such as the Microsoft Kinect™ on which our prototypes rely on. Hand gesture recognition is used to simplify interactions in the BLSD-S prototype (see Sect. 4.2.2). Automatic user's recognition obtained with CV algorithms is exploited to associate users to simulation roles (e.g., simulation that differentiates roles such as surgeon or nurse) and to re-identify the user in order to keep track of his/her performances in our Surgical Safety Checklist simulator (see Sect. 4.3). Dedicated hand-tracking cameras such as Leap Motion also represent a solid and low-cost solution to create gesture-based simulators using embedded tracking software. An example of this technology can be found in [48], where a gesture-based cataract surgery simulation is presented. We also exploit the Leap Motion in an advanced version of our BLSD-S (II) prototype, presented in Sect. 4.2.9.

2.3.2 Virtual Reality: New Perspectives

Virtual reality (VR) applications in the medical field have seen a growing interests. Although VR technology has been around for more than a decade, latest improvement in commercial hardware has greatly increased the possibility of new applications in critical fields. Nowadays, novel head-mounted displays (HMDs), such as the Oculus Rift or the Samsung Gear, offer very high-resolution graphics, low-latency performance, and accurate head tracking systems, allowing user to have a really realistic and immersive experience. More than two decades ago, Satava [41] proposed a pioneer application of virtual reality in medical simulation for anatomy lesson and surgical procedure simulation. The application adopted an early version of an HMD and sensorized gloves as a hand tracker input device. In his system evaluation, Satava highlighted two of the most critical limitations of VR technologies at that time: (1) The 3D computer graphics reduced the likelihood of the simulation caused by the low quality of the rendering, and (2) the limited resolution of the HMD decreased the quality of the visualization. Almost ten years after the first prototype of Satava, a randomized double-blind study was conducted [49] to assess the effect of VR training system in operating room performance. In the study, it was shown that students that were trained using a VR simulator significantly improved the performance during a laparoscopic cholecystectomy procedure. The improvement was attributable to the likelihood of the simulation and to the fact that this type of simulation and the isolation induced increases the level of concentration of the user.

As argued in a recent survey [50], many virtual reality simulators exploiting these new devices have been standardized and validated, showing clear positive outcomes in the medical training. As a quite valuable example, Vankipuram et al. [51] proposed a VR-based training simulator for advanced cardiac life support. The chosen scenario is a pretty common one in medical simulation, since it allows to simulate skills such as situational awareness and team cooperation in a critical situation and has some similarities to our BLSD-S prototype, presented in Sect. 4.2.2.

In concluding this chapter, it is important to point out that VR systems exploiting NI technologies can help trainees to develop certain skills in a safe and realistic environment, using natural gestures, and allow multiple repetitions of the simulation with no additional costs. However, it has to be clear that not every procedure equally

Table 2.1 Solutions adopt+ed by the different medical simulation systems

	Visualization			Interaction		
	3D Graphics	Immersive env	Virtual Reality	Mouse and Keyboard	Haptic device	Gesture-based
Cybermed [7]	✓			✓	✓	
SOFA [8]	✓			✓		
ViMet [9]	✓			✓	✓	
GiPSi [12]	✓	✓			✓	
Honey et al. [15]	✓	✓		✓		
Cowan et al. [16]	✓	✓		✓		
Spring [10]	✓	✓		✓		
JDoc [17]	✓	✓		✓		
Microsim [11]				✓		
Yanbin et al. [42]	✓					✓
Buttussi et al. [18]	✓	✓		✓		
LISSA [47]	✓					✓
Jayakumar et al. [48]	✓			✓		✓
Satava [41]	✓		✓			✓
Vankipuram et al. [51]	✓	✓	✓		✓	

benefits from such technologies. In fact, while the quality of the computer graphic is constantly improving and has reached a broadly accepted level of realism, interaction is still an issue with many simulators. In some scenarios, such as a surgical operation, simulator needs to provide a tactile feedback to the trainees in order for them to have real feeling of the tissue. In other cases, such as eye surgery or an intubation procedure, users need to perform actions that require a very high accuracy in activities understanding. In these scenarios, haptic devices are generally preferred to purely virtual methods which, anyway, are the main subject of this book and are discussed in Chap. 4.

In the next chapter, are presented in detail the computer vision methods for re-identification and the gesture recognition modules that have been used in our prototypes to improve interaction design and systems usability.

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